

**EXPLORING THE MOON IN THE 21<sup>ST</sup> CENTURY: THEMES, GOALS, INVESTIGATIONS AND PRIORITIES, 2008: THEME 2, USE THE MOON TO PREPARE FOR FUTURE MISSIONS TO MARS AND OTHER DESTINATIONS.** J. E. Gruener<sup>1</sup> and C. R. Neal<sup>2</sup>, [john.e.gruener@nasa.gov](mailto:john.e.gruener@nasa.gov), <sup>1</sup>Lunar Surface Systems Project Office, NASA Johnson Space Center, Houston, TX, 77058, <sup>2</sup>Department of Civil Engineering & Geological Sciences, University of Notre Dame, Notre Dame, IN, 46556.

**Introduction:** The Lunar Exploration Analysis Group (LEAG) has been asked by the NASA Advisory Council (NAC) to develop a lunar exploration roadmap, in support of the U. S. Space Exploration Policy. The purpose of the roadmap is to map science goals defined by NASA, the NAC, the National Research Council and others [1-3], to objectives, observations and measurements, and will include an assessment of needed technology developments, areas of potential coordinated activities for commercial and international participation, and potential feed-forward activities for the exploration of Mars and beyond. The LEAG Executive Committee (for details see <http://www.lpi.usra.edu/leag>) has formulated the themes and goals for the roadmap, which have been placed on the Lunar and Planetary Institute (LPI) web site and opened for public comment. The themes include: Theme 1 - Pursue scientific activities to address fundamental questions about the solar system, the universe, and our place in them; Theme 2 - Use the Moon to prepare for future missions to Mars and other destinations; Theme 3 - Extend sustained human presence to the Moon to enable eventual settlement.

**Roadmap Theme 2: Use the Moon to prepare for future missions to Mars and other destinations.**

As mentioned in NASA's Exploration Systems Architecture Study (ESAS) report [4], "The Moon and Mars are two very different planetary environments, but the operational techniques and exploration systems needed to work and live on both surfaces will have similar strategies and functions. It is not likely that exact 'copies' of Mars-bound systems will be operated or tested on the Moon. However, it is very likely components and technologies within those systems ultimately destined for the surface of Mars will undoubtedly find their heritage based on lunar surface operations. The philosophy then is to do what is proper and required for the lunar environment and use the knowledge, experience, and confidence gained from operations on the Moon as the foundation for the design of surface systems for Mars and other destinations in the solar system."

The LEAG Executive Committee has thus establish two goals within the theme of using the Moon to prepare for future missions to Mars and other destinations.

One goal focuses on the technologies and systems aspect of the theme, or the 'hardware', while the other goal focuses on mission operations and exploration techniques.

**Goal 2a: Identify and test technologies on the Moon to enable robotic and human solar system science and exploration.** There is a need to develop technologies and systems to a sufficiently mature stage for flight so as to be ready for surface and orbital operations. A smooth pathway is necessary to bring identified technologies to a high technology readiness level (TRL) so their development and incorporation into complete systems does not hinder progress in the exploration of the solar system and/or achieving science goals. This is particularly important for feed-forward technologies and systems for the exploration of Mars and beyond.

The Moon will serve as a test bed for technologies that will enable sustained human exploration of Mars and beyond. These technologies include closed-loop life support and in-situ resource utilization systems to reduce the mass of consumables that must be resupplied from Earth, fission surface power systems to provide abundant power far from the sun, advanced robotics for assembly and maintenance of remote outposts, surface mobility and EVA systems that will allow the crew to explore regions hundreds of kilometers away from their outpost, and habitation systems to enable the crew to live and work in hazardous environments on long-duration missions.

**Goal 2b: Use the Moon as a test-bed for missions operations and exploration techniques to reduce the risks and increase the productivity of future missions to Mars and beyond.** While the Moon and Mars have different gravities and drastically different environments and soil properties, both are still hostile environments that require similar functional capabilities for humans to explore and live off Earth. The nearness of the Moon with respect to Earth allows for opportunities in testing exploration techniques and functional capabilities without the concern that help from Earth or the ability of the crew to return safely is more than a year away. The purpose of this goal is to evaluate what general mission operations and exploration

techniques can be tested on the Moon to enhance the future successes of missions to Mars and beyond.

Exploration crews living on the moon offer a unique opportunity to study and understand human behavioral adaptation to space in an operational realistic setting, with the goal of understanding, enhancing and maintaining crew behavioral health during extended-duration missions. Both ISS and ground-analogs offer platforms to compare and amplify lessons learned in lunar studies about living and performing in isolated and confined micro-societies over 2-3 year periods. The lunar outpost missions also offer a unique environment to facilitate collection of human biomedical data over extended periods and validate biomedical capabilities for autonomous health care during exploration missions.

**References:** [1] The Global Exploration Strategy: The Framework for Coordination (2006), [www.nasa.gov/pdf/178109main\\_ges\\_framework.pdf](http://www.nasa.gov/pdf/178109main_ges_framework.pdf). [2] NASA Advisory Council Workshop on "Science Associated with the Lunar Exploration Architecture" (2007) <http://www.hq.nasa.gov/office/oer/nac/>. [3] National Research Council report "The Scientific Context for Exploration of the Moon" (2007) National Academies Press. [4] Exploration Systems Architecture Study (ESAS) report (2005), [http://www.nasa.gov/mission\\_pages/exploration/news/ESAS\\_report.html](http://www.nasa.gov/mission_pages/exploration/news/ESAS_report.html).